

## UNIT III: SOLUBILITY

### REVIEW PROBLEMS (3.1-3.8)

1. Identify each of the following as ionic, partially ionic, or molecular substances.

	a) $\text{NaCl}_{(aq)}$	ionic	$\text{NaCl}_{(aq)} \rightarrow \text{Na}^+_{(aq)} + \text{Cl}^-_{(aq)}$
organic acid $\rightarrow$	b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}_{(aq)}$	partially ionic molecular	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}_{(aq)} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-_{(aq)} + \text{H}^+_{(aq)}$
	c) $\text{CCl}_4(l)$	molecular	$\text{CCl}_4(l) \rightarrow \text{CCl}_4(aq)$
polyatomic $\rightarrow$	d) $\text{HNO}_3(aq)$	ionic	$\text{HNO}_3(aq) \rightarrow \text{H}^+_{(aq)} + \text{NO}_3^-_{(aq)}$
	e) $\text{C}_2\text{H}_6(g)$	molecular	$\text{C}_2\text{H}_6(g) \rightarrow \text{C}_2\text{H}_6(aq)$

(2 s.f.)  
(3.0M) 2. A chemistry stockroom contains a bottle of 12.0 M HCl. A teacher needs to make up 800.0 mL of a 3.0 M solution of HCl. What volume of the stock solution (12.0 M) does the teacher need to use?

$$C_1 V_1 = C_2 V_2$$

$$C_1 = 12.0 \text{ M}$$

$$C_2 = 3.0 \text{ M}$$

$$V_1 = ?$$

$$V_2 = 800.0 \text{ mL}$$

$$(12.0 \text{ M})(V_1) = (3.0 \text{ M})(800.0 \text{ mL})$$

$$\frac{12(V_1)}{12} = \frac{2400}{12}$$

$$V_1 = 200 \text{ mL} = \underline{2.0 \times 10^2 \text{ mL}} \text{ or } \boxed{0.20 \text{ L}}$$

(2 s.f.) 3. If 25.0 mL of 0.90 M HCl is added to 125.0 mL of water, what is the final [HCl]?

$$C_1 V_1 = C_2 V_2$$

$$C_1 = 0.90 \text{ M}$$

$$C_2 = ?$$

$$V_1 = 25.0 \text{ mL}$$

$$V_2 = 125 \text{ mL} + 25 \text{ mL} = 150.0 \text{ mL}$$

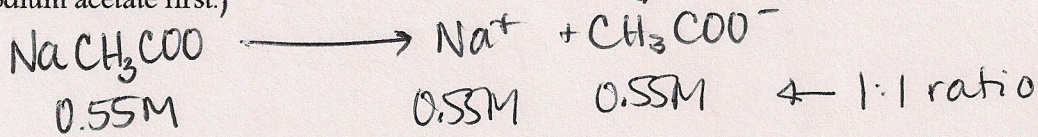
$$C_2 = \frac{C_1 V_1}{V_2} = \frac{(0.90 \text{ M})(25.0 \text{ mL})}{(150.0 \text{ mL})}$$

$$[\text{HCl}] = \boxed{0.15 \text{ M}}$$



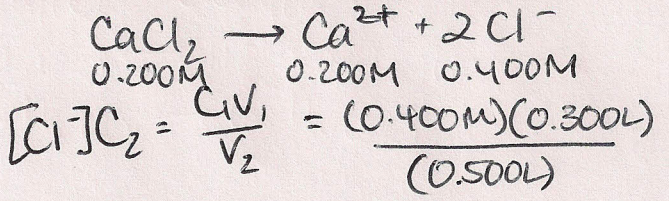
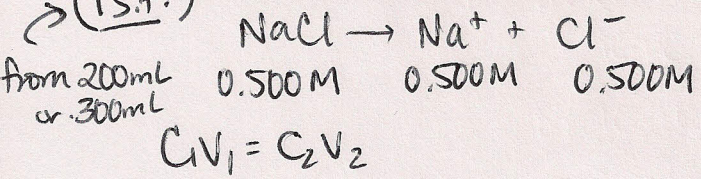
ANSWERS & EXPLANATIONS

4. Calculate the  $[Na^+]$  in a 0.55 M solution of sodium acetate. (Write the proper formula for sodium acetate first.)



$$[Na^+] = \boxed{0.55M}$$

→ (1s.f.) 5. 200 mL of 0.500 M NaCl is mixed with 300 mL of 0.200 M CaCl<sub>2</sub>. Calculate the final total  $[Cl^-]$ .



$$[Cl^-]C_2 = \frac{C_1V_1}{V_2} = \frac{(0.500M)(0.200L)}{0.500L}$$

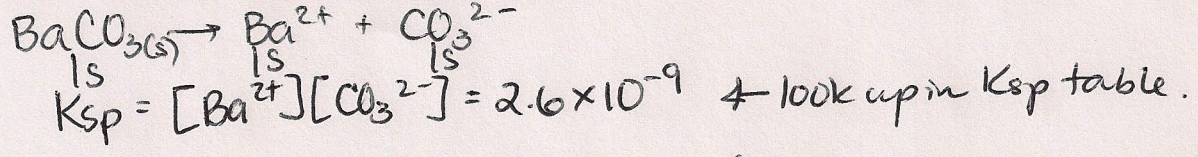
$$[Cl^-] = 0.240M$$

$$[Cl^-] = 0.200M$$

$$\text{total } [Cl^-] = 0.200 + 0.240 = 0.440M$$

$$1 \text{ sig fig} = \boxed{0.4M}$$

6. Calculate the molar solubility of BaCO<sub>3</sub> in water.



$$2.6 \times 10^{-9} = [Ba^{2+}][CO_3^{2-}]$$

(molar solubility = equilibrium concentration @ saturation in mol/L)

1:1 ratio  
so each ion concentration is "s"

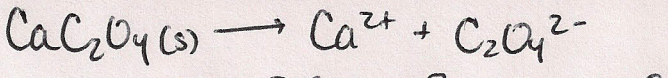
$$2.6 \times 10^{-9} = (s)(s)$$

$$2.6 \times 10^{-9} = s^2$$

$$s = \sqrt{2.6 \times 10^{-9}} = 5.1 \times 10^{-5}$$

$$[BaCO_3] = \boxed{5.1 \times 10^{-5} M}$$

7. Calculate the number of grams of CaC<sub>2</sub>O<sub>4</sub> which will dissolve in 1.5 L of water at 25 °C.



$$K_{sp} = [Ca^{2+}][C_2O_4^{2-}] = 2.3 \times 10^{-9}$$

$$2.3 \times 10^{-9} = (s)(s)$$

$$2.3 \times 10^{-9} = s^2$$

$$s = \sqrt{2.3 \times 10^{-9}} = 4.8 \times 10^{-5}$$

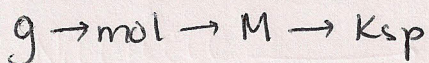
(\* calculate molar solubility of CaC<sub>2</sub>O<sub>4</sub>, then convert to g/(1.5L\*))

$$[CaC_2O_4] = \frac{4.8 \times 10^{-5} \text{ mol}}{L} \times \frac{128.1g}{1 \text{ mol}} \times \frac{1.5L}{1}$$

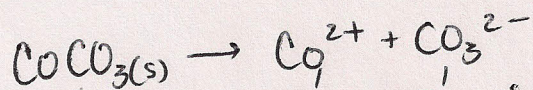
$$= \boxed{9.2 \times 10^{-3} \text{ g } CaC_2O_4}$$



- (4 s.f.) 8. The solubility of  $\text{CoCO}_3$  in water is  $1.189 \times 10^{-3}$  grams per liter. Calculate the  $K_{sp}$  for  $\text{CoCO}_3$ .



$$\frac{1.189 \times 10^{-3} \text{ g}}{1 \text{ L}} \times \frac{1 \text{ mol}}{118.9 \text{ g}} = 1.000 \times 10^{-5} \text{ mol/L} \quad \leftarrow \text{molar solubility}$$

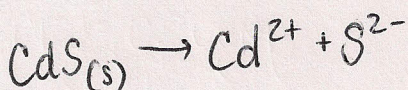


$$K_{sp} = [\text{Co}^{2+}][\text{CO}_3^{2-}] \quad (1:1 \text{ molar ratio})$$

$$= (1.000 \times 10^{-5} \text{ M})(1.000 \times 10^{-5} \text{ M}) = \boxed{1.000 \times 10^{-10}}$$

- (4 s.f.) 9. It is found that  $1.892 \times 10^{-13}$  grams of the compound cadmium (II) sulphide ( $\text{CdS}$ ) will dissolve in 350.0 mL of water to form a saturated solution. Using this data, calculate the value for the  $K_{sp}$  of  $\text{CdS}$ .

$$\frac{1.892 \times 10^{-13} \text{ g CdS}}{0.3500 \text{ L}} \times \frac{1 \text{ mol}}{144.5 \text{ g}} = 3.741 \times 10^{-15} \text{ M (molar solubility)}$$



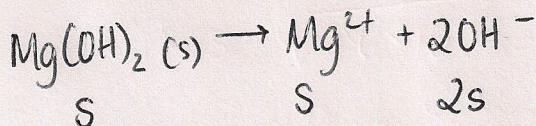
$$\begin{array}{ccc} 3.741 \times 10^{-15} \text{ M} & 3.741 \times 10^{-15} \text{ M} & 3.741 \times 10^{-15} \text{ M} \end{array}$$

$$K_{sp} = [\text{Cd}^{2+}][\text{S}^{2-}] =$$

$$K_{sp} = (3.741 \times 10^{-15})(3.741 \times 10^{-15}) = \boxed{1.399 \times 10^{-29}}$$

(\*convert g/mL to mol/L - molar solubility  
- use molar solubility to calculate  $K_{sp}$  value using molar solubility\*)  
 $g \rightarrow \text{mol} \rightarrow M \rightarrow K_{sp}$

- (4 s.f.) 10. Calculate the maximum mass of  $\text{Mg}(\text{OH})_2$  which will dissolve in 150.0 mL of water. Show all of your steps clearly.



$$K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$$

$$5.6 \times 10^{-12} = (s)(2s)^2$$

$$5.6 \times 10^{-12} = 4s^3$$

$$s = \sqrt[3]{\frac{5.6 \times 10^{-12}}{4}} = 1.119 \times 10^{-4} \text{ M}$$

$$\text{mol} = (M)(V)$$

$$= (1.119 \times 10^{-4} \text{ M})(0.1500 \text{ L})$$

$$= 1.678 \times 10^{-5} \text{ mol}$$

$$\text{mass} = 1.678 \times 10^{-5} \text{ mol} \times \frac{58.3 \text{ g}}{1 \text{ mol}}$$

$$= \boxed{9.783 \times 10^{-4} \text{ g}}$$

calculate molar solubility

convert to grams/0.150L